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HETCH HETCHY WATER & POWER

WATER SUPPLY, DEMAND AND THE FUTURE:

A SUMMARY OF CURRENT CONDITIONS, PRIOR WORK, AND THEIR IMPLICATIONS FOR FUTURE WATER SUPPLY POLICY

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EXECUTIVE SUMMARY

In the early 1900's San Francisco started the process of acquiring rights to unappropriated water on the Tuolumne River. This was necessary in order to augment local supplies which had proved inadequate to reliably serve its growing population.

Today, Hetch Hetchy and the San Francisco Water Department provide over 75% of the water consumed by San Francisco and 33 suburban water agencies in Alameda, San Mateo and Santa Clara Counties; a service area that includes 2.3 million people.

Reliability of water supplies is again a concern. There have been two serious droughts in the past 15 years and the Water Department has had to impose rationing in five of the last six years.

Hetch Hetchy and the Water Department have had to reassess the ability of their systems to meet the demand for water during droughts as well as the increased demand for water that can be expected in the next several decades. The conclusion is that water demand is already in excess of the system's safe yield and will continue to grow gradually over the next 20 years.

Safe yield is defined as the amount of water that a system can provide without deficiencies (i.e. rationing) through wet and dry periods.

Revised studies of Hetch Hetchy's safe yield, which incorporate hydrology from the current drought and real life operating constraints, have lowered the estimate of safe yield to about 240 mgd.

The import of this is that San Francisco and its suburban customers now have to plan on periodic deficiencies, and that as demand increases these deficiencies will be more frequent and more severe.

The alternatives are to limit demand, acquire additional water supplies or build additional facilities.

The current drought has given important lessons on the level and duration of supply deficiency that is acceptable in the service area. The 25% rationing program has proven successful thus far;

but it is questionable as to whether this level of rationing will be tolerated much longer during the current drought or whether the spector of this level of rationing, on a repetitive basis, would be acceptable. Moreover, the brief experience with a 45% rationing plan in the spring of 1991 convinced San Francisco's water managers that such a program would have inflicted unacceptable personal and economic harm. This feeling was confirmed by a study of the effect of water curtailments by Spectrum Economics.

In managing the current drought, San Francisco's customers have utilized conservation, reclamation, ground water and water transfers (purchases).

In looking to the future, these same measures will have to become a permanent part of the Bay Area's water management plan. If these measures are pursued aggressively, it may be possible to produce a net rate of savings that will hold Bay Area demand below system capacity for several decades.

However, herein lies a paradox. Operating above the system's capacity, as currently is the case, requires by definition that the Bay Area be able to take periodic deficiencies. But, if San Francisco and its customers manage to stay within system capacity in spite of growth by implementing permanent conservation measures, the Bay Area's ability to absorb deficiencies will be reduced since critical water use reduction methods will already be in place.

There is a limit on the level of demand that can be met with existing facilities at an acceptable level of periodic supply deficiency. It is likely that Bay Area demand is very near that limit today.

Developing new supplies is both time consuming (decades) and very expensive. This report summarizes current conservation activities as well as prior proposals for new facilities. Taken together, this is an indication of water supply options that may be available to deal with San Francisco's long term water supply needs. It is also a starting point for assessing future water supply options.

Water supply projects have often been built at a cost to the environment. San Francisco's water supply system is remarkably benign environmentally, in part because of the Raker Act entitlement structure which limits project diversions during periods of low river flows. But, taken as a whole, California's environment has suffered from its water development and the Bay Area has a stake in finding and supporting solutions to these problems.

Because of the supply situation discussed above, Hetch Hetchy is not in a position to contribute water from its existing facilities for environmental improvements. But, as plans are made to

secure future supplies provision will have to be made for the environment. And in the mean time, there may be non-water contributions that San Francisco can and should make.

Consideration of these options suggests five essential elements of a viable water supply policy:

1) Hetch Hetchy and the City Attorney should resist all attempts to divert existing project yield to new or expanded purposes.

2) The Water Department should continue and expand current efforts in conservation, reclamation, and ground water development in a committed attempt to stabilize net system demand at or near current levels.

3) Hetch Hetchy needs to pursue "dry year options" and other forms of supply augmentation that will increase safe yield to at least the level of current system capacity. This is in recognition of the resulting, decreased ability of the service area to sustain supply deficiencies as increased conservation "hardens" the service area's water demand.

4) In order to deal with the likelihood that these necessary steps will prove insufficient, Hetch Hetchy, the Water Department and the Bay Area Water Users Association need to evaluate the need and possibilities for increasing supplies. This could be in the form of increasing Hetch Hetchy's capacity or increasing the suburban water agencies' ability to utilize other supplies. Population trends, land use and environmental considerations need to be part of this evaluation.

5) Hetch Hetchy and the Water Department should work together with other California water and environmental interests to identify opportunities for financial participation in projects that will create new water or facilities that will contribute to the restoration of environmental conditions in the San Joaquin River Basin and in the Bay/Delta Estuary. Future water projects should be designed with the intent of improving environmental conditions where feasible.

1.0 INTRODUCTION

1.1 Purpose of the Report

This report summarizes previous water resource studies and condenses the recommendations outlined in these studies for follow-on activities by the Water Department and Hetch Hetchy Water and Power staff.

1.2 Content of the Report

The six sections of this report are:

1.0 • Introduction

2.0 • Background information on the local water system,

3.0 • Consequences and results of the water supply shortage,

4.0 • Projects and programs capable of expanding water supply, and

5.0 • Conclusion.

The supporting material for this report comes from various reports, studies, and internal documents compiled by the San Francisco Water Department (SFWD), Hetch Hetchy Water and Power (HHWP), and a number of consultants to the SFWD.

2.0 BACKGROUND INFORMATION ON THE LOCAL WATER SYSTEM

To give a complete picture of the water supply situation in the City of San Francisco and its vicinities, the following section describes the history and physical facilities of the water supply system.

2.1 History of the San Francisco Water Supply System

In the late 1800's, as the City of San Francisco was expanding and developing into a major metropolitan area, the shortage of water became an apparent problem. San Francisco performed numerous studies and investigations to gain insight into ways of increasing the City's water supply. Farsighted civic leaders began to realize that the only satisfactory solution to the problem was municipal ownership of a reliable source of water supply. The Spring Valley Water Company, which provided local water service, owned or controlled all local Bay Area water sources as far away as the Coast Range in Alameda County. Therefore, San Francisco decided to look beyond the Coast Range for a future water supply — to the Sierra Nevada along California's eastern border.

San Francisco investigated 14 possible water sources during 1900 and 1901. This investigation recommended the Tuolumne River system — later called Hetch Hetchy — for the following basic reasons:

- Quality of the water,
- Protected watershed,
- Largest amount of water available,
- Largest and finest reservoir sites,
- Freedom from conflicting legal claims,
- Hydro-electric power possibilities, and
- Comparatively low developmental costs.

In 1900, San Francisco started the process of acquiring the rights to unappropriated water on the Tuolumne River. During this process, the City met opposition from various factions: Modesto Irrigation District (MID) and Turlock Irrigation District (TID), the major holders of Tuolumne River water rights at that time; Spring Valley Water Company, owner of all local Bay Area water sources; and environmentalists, who wanted to preserve the pristine beauty of the Hetch Hetchy Valley. On August 1, 1913, John Raker of Manteca introduced Bill HR7207, which not only met

the needs of San Francisco by granting the City development rights on the Tuolumne River, but also overcame most of the major objections of those opposing the Hetch Hetchy project. While special provisions ended the opposition from the MID, TID, and the Spring Valley Water Company, environmentalists still fervently opposed the Bill. Even as the environmentalists argued against the Hetch Hetchy project, the House of Representatives and the Senate respectively adopted the Act on September 3 and December 2 of 1913.

Entitled the "Hetch Hetchy Act," but more popularly known as the Raker Act, the Act imposes several conditions and obligations, including:

- San Francisco must recognize the prior rights of MID and TID to receive water up to specified amounts of the natural daily flow, for direct use and storage to the extent they can beneficially use same.
- San Francisco must construct and maintain scenic roads and trails in Yosemite National Park, and donate them to the United States.
- San Francisco must first rely on its locally developed water sources before relying on its Tuolumne River supplies.

On December 6, 1913, President Woodrow Wilson signed the Raker Act into law and the City of San Francisco accepted its conditions in the Spring of 1914. Construction of the Hetch Hetchy project, designed as a 400 million gallons per day (mgd) water system, commenced immediately after the ratification.

2.2 Description of the Water Supply System

Today, as the first designers had envisioned, the heart of the San Francisco water system lies in the Sierra Nevada Range. The source of the water is the Tuolumne River, which originates from glaciers on Mount Lyell within the Yosemite National Park. This River and its tributaries drain into three reservoirs: Hetch Hetchy, Lake Lloyd and Lake Eleanor.

Lake Lloyd and Lake Eleanor Reservoirs are normally operated to meet the Raker Act water entitlements of MID and TID. Hetch Hetchy Reservoir provides over 75% of the water for San Francisco and its suburban customers. Along with local Bay Area reservoirs, and with exchange storage in New Don Pedro Reservoir gained through a joint project with MID and TID, San Francisco's total storage capacity stands at approximately 1.47 million acre feet (AF).

A network of pipelines and tunnels transports water from the Sierra reservoirs to the SFWD service area. As constructed, the aqueduct has the capability of meeting a peak demand of 300 mgd and an average demand of 270 mgd. In fiscal year 1991 with mandatory rationing enforced, the system delivered an average of 205 mgd, of which two-thirds were used by the suburban customers. The San Francisco Water System is shown in Figure 1.

The SFWD and Hetch Hetchy system supplies water to the City and County of San Francisco and to 33 suburban agencies in Alameda, San Mateo and Santa Clara Counties. These 33 agencies, shown in Figure 2, comprise the Bay Area Water Users Association (BAWUA). The relative flows of the water system to San Francisco and to the suburban customers are illustrated in Figure 3.

San Francisco Water System

Figure 1

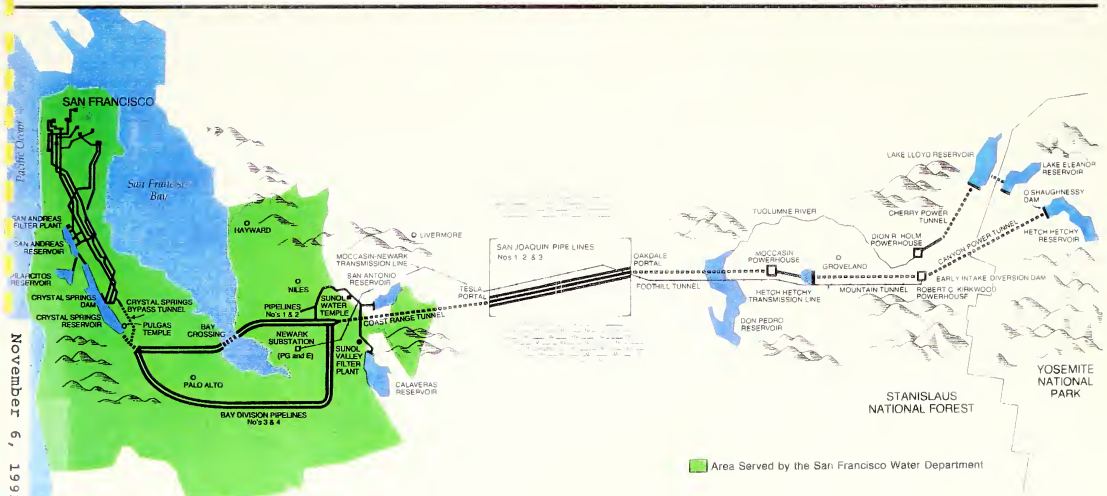
S F WATER DEPT CITY RESERVOIRS	
NAME	Capacity Million gallons
LAKE MERCED *	2,563.0
SUNSET	174.8
UNIVERSITY MOUND	140.9
SUTRO	31.4
SUMMIT	14.0
COLLEGE HILL	14.1
STANFORD HEIGHTS	12.9
MERCED MANOR	9.3
LOMBARD	3.3
FRANCISCO	2.3
POTRERO	1.0
MCLAREN PARK	8.0
HUNTERS POINT	1.1

* EMERGENCY

HETCH HETCHY RESERVOIRS						
NAME	DAM		CAPACITY			PURPOSE
	TYPE	HEIGHT (FT)	ELEVATION	HIGH FWL	VOL. OF SEL.	
HETCH HETCHY	CONCRETE GRAVITY	430	910	360,360	117,400	HYDROPOWER
LAKE LLOYD	CONCRETE EARTH & ROCK	330	2,600	288,800	87,600	HYDROPOWER
LAKE ELEANOR	CONCRETE BUTTRESS ARCH	70	1,260	27,100	8,830	HYDROPOWER
INTAKE	CONCRETE ARCH	81	262	115	37	DIVERSION
PRIEST	CONCRETE EARTH & ROCK	160	1,160	1,055	345	REGULATING
MOCCASIN	CONCRETE EARTH & ROCK	70	895	505	165	RE-REGULATING

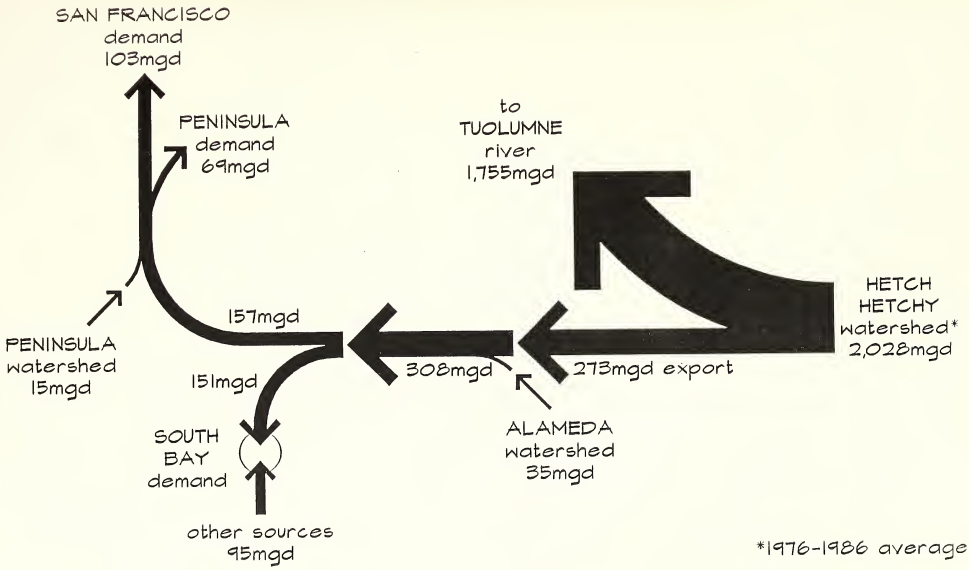
S F WATER DEPT STORAGE RESERVOIRS IN BAY AREA	
NAME	CAPACITY
	Acre-Feet / Million gallons
CALAVERAS	96,850 / 31,560
CRYSTAL SPRINGS	69,300 / 22,580
SAN ANDREAS	19,000 / 6,190
PILARCITOS	3,100 / 1,010
SAN ANTONIO	50,500 / 16,455

HETCH HETCHY AQUEDUCT - DISTANCES IN MILES O'SHAUGHNESSY DAM TO CRYSTAL SPRINGS RESERVOIR							
POINTS ON LINE	DIVISION	TUNNEL	PIPE	FLUME SIPH	CANAL	TOTAL DISTANCE	FROM PREVIOUS POINT
O'SHAUGHNESSY DAM							0.00
EARLY INTAKE	CANYON	10.64	0.43			11.07	11.07
PRIEST RESERVOIR	MOUNTAIN	18.81	0.04			18.85	29.92
MOCCASIN RES	MOCCASIN	1.03	.02	0.57		2.62	32.54
OAKDALE PORTAL	FOOTHILL	15.85	.45			16.30	48.84
TESLA PORTAL	SAN JOAQUIN			47.51		47.51	96.35
IRVINGTON PORTAL	COAST RANGE	28.64	.39			29.03	125.38
PULGAS E PORTAL	BAY CROSSING		21.24			21.24	146.62
CRYSTAL SPRGS RES	PENINSULA	17.1			0.18	1.89	148.71
	TOTAL	76.68	71.28	0.57	0.18	148.71	



SAN FRANCISCO'S SUBURBAN CUSTOMERS (BAWUA)
Figure 2

SAN FRANCISCO WATER FLOWS
Figure 3

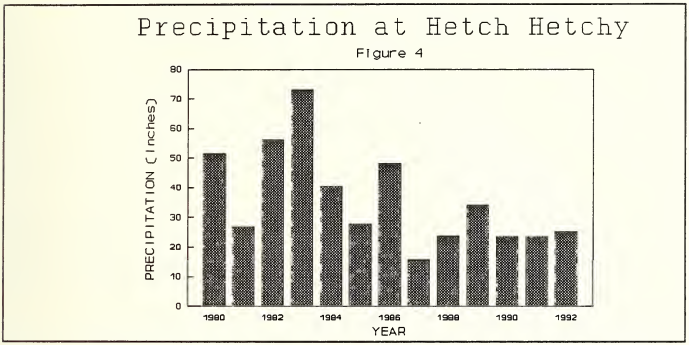


*1976-1986 average

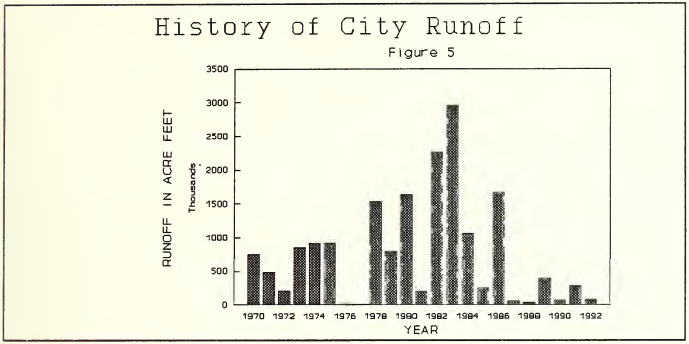
3.0 CONSEQUENCES AND RESULTS OF THE WATER SUPPLY SHORTAGE

3.1 Affects of the Drought on the Water Supply System

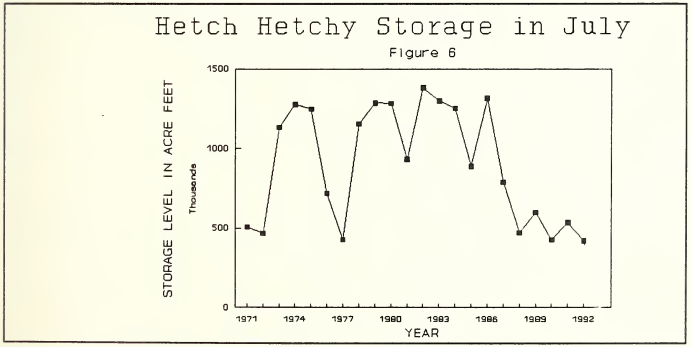
With six consecutive drought years since the beginning of 1987, San Francisco's water supply has substantially decreased. The decline in precipitation at Hetch Hetchy during the current drought is shown in Figure 4.



Recent figures on Tuolumne River runoff and system storage also indicate the reduction in water supply. In a normal rainfall year, San Francisco's share of the Tuolumne is 762,000 AF, or about twice the amount of water used by the San Francisco's service area. The City's share of runoff between 1987 and 1991 totalled just 816,608 AF or approximately 10% more than one normal year's runoff. In 1988, the worst year of the current drought in terms of runoff, the City received 31,040 AF from the Tuolumne, which is only 4% of a normal year's share. A history of the City's share of Tuolumne River runoff is shown in Figure 5.



This reduction in the City's share of runoff has lowered the amount of water stored in the Sierra reservoirs. A history of the City storage at Hetch Hetchy, including water in the New Don Pedro Reservoir, is illustrated in Figure 6.



The graph shows that since 1986, when storage level was near full capacity, the drought has considerably diminished the amount of water stored in the reservoirs.

The most immediate and direct effect of reduced runoff and storage has been the necessity to enforce rationing in five of the past six years.

In 1988, one year after the beginning of the current drought, the San Francisco PUC adopted the first water rationing program for the SFWD service area. This plan called for a 10% reduction in inside water use and a 60% reduction in outside water use compared to 1987 water consumption levels. To meet the 25% system-wide reduction goal, water use restrictions[1] and a charge for water use above allocations were enforced. Higher levels of precipitation and an increase in storage levels allowed the PUC to terminate the rationing plan in 1989, but with the continuation of the drought into 1990, the 25% rationing program again took effect on May 8, 1990.

Even though the rationing plan was largely successful (24% system-wide reduction versus the stated goal of 25%), the PUC adopted a plan on February 26, 1991 to reduce system-wide consumption by 45% compared to 1987 water use. The more stringent rationing was compelled by the extremely low storage levels at that time (on February 28, 1991, storage at Hetch Hetchy was down to 24,600 AF or about 6.8% of capacity). To obtain the 45% decrease in water consumption, the plan mandated a 33% reduction in inside use and a 90% reduction in outside use. Due to the combination of an increase in expected runoff, water transfers, and the "March Miracle", the PUC discontinued the 45% plan and reverted to the 25% reduction plan on April 23, 1991.

3.1.1 Safe Yield

A more lasting effect of the drought is that Hetch Hetchy and the Water Department have had to reassess the yield of the water supply system.

Safe yield is the amount of water that can be provided on a reliable basis. It is a function of hydrology, facilities, and operating constraints.

It is common that safe yield studies calculate the amount of water that can be delivered from existing facilities without

---

[1]Prohibitions of flooding or runoff into the streets and gutters, withholding water service connections for new construction unless water saving devices are incorporated into plumbing system, and prohibitions of the use of potable water whenever reclaimed water or ground water could be substituted.

rationing during a design drought. At the end of the drought, all reservoirs would be empty. This is a useful way of quantifying the ultimate capacity of a water supply system, but it is an imprudent way of operating a water supply system in that it provides no margin for error. If a drought turned out to be longer than any on record, the system would run out of water.

Prior to the current drought, the safe yield of the Hetch Hetchy system was believed to be almost 400 mgd. This figure was confirmed by studies conducted after the 1976/77 drought.

Beginning in 1989, Hetch Hetchy began a process of modeling its Tuolumne River facilities in order to establish a yield that reflected revised hydrology, realistic operating constraints, and the reliability needs of its highly urbanized service area.

The result of this effort has been to reduce the estimate of safe yield to 235 mgd. This reduction is due to the following:

Old safe yield analysis	400 mgd
Various modeling corrections	(24)
Inclusion of current drought hydrology	(71)
Inclusion of reliability criteria	(65)

Revised safe yield	240 mgd

Of these adjustments the reliability criteria is the most difficult. The modeling corrections were technical, the inclusion of current drought hydrology was routine, but the reliability criteria posed unique analytical and judgmental problems.

The question is how much risk is acceptable in the operation of the water system. Risk is the combination of probability of an adverse event and its consequence. In the case of urban water supply utilities, the consequence of running out of water is so severe that water systems must be operated with extremely low probability of failure.

The usual safe yield procedure was modified so that rather than running out of water in a critical drought, sufficient water remained in storage to provide a minimum level of water supply through an additional, critically dry period. The minimum level of water supply was defined as that necessary after imposing 30% mandatory rationing. The additional critically dry period was defined as the 1976/77 drought.

The resulting safe yield is the amount of water that can be provided, (1)without rationing during the worst drought of record, (2)leaving enough at the end of that drought to permit continued operation through another drought like 1976/77, (3)with

a response no more severe than 30% rationing. The margin of safety thus provided is considerable but not total.

Operating above safe yield means that there will have to be some deficiencies (i.e. rationing) imposed during dry periods no more severe than those on record. As demand increases without the addition of facilities, these deficiencies will have to become more frequent and/or more severe. Using the yield model, we have been able to define operating criteria that require deficiencies more frequently in order to limit their severity.

3.1.2 Demand Forecast

The drought has also caused the Water Department to change its water demand projections for the service area.

In-City demand projections were made for the City by Bookman-Edmonston Engineering and Sierra Hydrotech in cooperation with City staff. Suburban demand projections were made by Hilton, Farnkopf, and Hobson under contract to the Bay Area Water Users Association. These suburban projections are preliminary and under continuous review by the Bay Area Water Users Association.

Both in-City and suburban demand are expected to recover somewhat after the drought ends. After that, City demand is expected to grow very slowly. Suburban demand is expected to show the most growth; about 11% from 1995 to 2010. Figure 7 shows these trends.

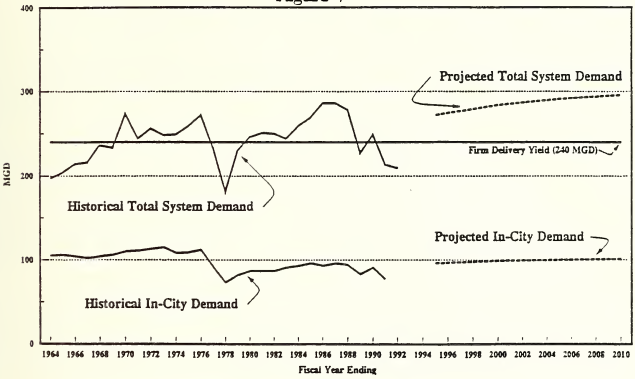
The suburban demand projection was segregated by source of supply. These projections show the suburban agencies increasing their demand on San Francisco's system up to their contractual supply assurance (184 mgd) by the year 2010. The rest of their demand growth will be met by water taken from the Delta either by the State Water Project or through Santa Clara Valley Water District. The table, below, shows that these two sources will be called on to handle the majority of demand growth between now and 2010.

Demand Protection
Bay Area Water Users
(Average Annual MGD)

Source of Supply	1985	1990	1995	2000	2005	2010
SFWD	175	134	166	175	181	185
SCVWD	12	15	19	21	23	24
SWP (treated water)	9	9	29	32	32	32
Groundwater	59	51	48	54	56	57
Surface Water	2	2	2	2	2	2
Reclaimed Water	0	1	7	8	8	8
TOTAL	257	212	271	292	302	308

Figure 7 shows actual and projected demand in relation to the system firm yield of 240 mgd. Note that post-drought demands are expected to be well above this level.

City and County of San Francisco
Historical and Projected Water Demands
Figure 7



What this means for San Francisco and our suburban customers is that we already have to plan on periodic deficiencies; and that as demand increases, these deficiencies will be more frequent and more severe. Further, in the very near future we will have to evaluate our response to the likelihood of total demand exceeding existing system capacity.

3.1.3 Other Demands on the Tuolumne River Supply

The Hetch Hetchy system was designed and built in an era of great enthusiasm for public works. In spite of the concerns expressed by John Muir and others, the development of California's water resources continued with vision and zeal for the next fifty years.

In the more recent past, water development has become more difficult, essentially coming to a halt, and there is increasing public support and policy for mitigating some of the environmental effects caused by water projects.

The public trust doctrine potentially exposes all water rights and uses to judicial review. The interim standard setting phase of the Bay/Delta hearing now being conducted by the State Water Resources Control Board (SWRCB) will include review of Hetch Hetchy and other pre-1914 rights holders in their consideration of impacts on the Bay and Delta. It is possible that the SWRCB will attempt to affect San Francisco's water operation to benefit environmental uses.

Additional pressures on our Tuolumne River supply will come from other sources. These include the hearings that are about to commence at the Federal Energy Regulatory Commission (FERC) on the subject of New Don Pedro fish releases and possible actions which may be precipitated by the San Joaquin Fish and Restoration Project.

San Francisco recognizes its interest in environmental restoration and is in sympathy with efforts directed at environmental restoration. Over the years San Francisco has agreed to increase its fish release obligations to the upper Toulumne River. It has also worked with the rafting industry to make the rafting season extend into the summer and has adjusted its generation schedules so that water is provided to the stream when the rafters most need it.

The demand and supply picture presented in this report places San Francisco in the unfortunate position where it cannot afford to make any additional contribution of water for environmental purposes. All of the "creative" measures available to San Francisco to increase supply, especially in the short term, will be needed to recover from the reduction in project yield resulting from the current drought. It is reasonable that as San Francisco develops additional supplies a portion of their yield may be available for environmental mitigation. It would be San Francisco's intent to consider such a possibility.

In the short term, San Francisco must defend its municipal water rights against any and all attempts to allocate developed supplies to any other purpose. At the same time, however, San Francisco may be able to make financial contributions to projects where there is room for the creation of environmental water, environmentally beneficial projects (such as wetlands) or facilities.

Such an ability to "purchase environmental credits" would serve the public interest as well as the interests of San Francisco.

3.2 Public Response to the Drought

Not only has the drought affected the water supply system, but it has altered people's way of life as well. During the early months of 1991, two events significantly raised the public's

awareness of the drought: first, due to an extremely dry winter, the San Francisco Public Utilities Commission (PUC) adopted a new rationing program in February, calling for a 45% water use reduction; second, heavy precipitation in March, sometimes referred to as the "March Miracle," enabled the PUC to end the 45% reduction plan and revert to the previously imposed 25% reduction plan. The effect of the these events was clearly evident in a poll performed by the San Francisco Chronicle between April 2 and April 4 of 1991. According to the poll, the drought was then the number one worry among Bay Area residents, topping drugs, jobs and the economy, schools, crime and housing. The poll revealed that of the Bay Area residents surveyed, 18% listed the drought as the top concern, while drugs, the second-highest top concern, came in at a distant 12%. As recently as January, traffic had been the top concern at 15%, while the drought was only at 10%.

Due to tightened water restrictions necessitated by the drought, few people have escaped feeling the brunt of the restrictions.

To gain a better perspective of the public response to ways of extending the SFWD's water supplies, the SFWD in cooperation with BAWUA and the San Francisco Clean Water Program held eight public meetings. Between October 16 and December 4, 1990, two meetings were held in each of the four counties served by the SFWD — San Francisco, San Mateo, Santa Clara, and southern Alameda. The results of these meetings, documented in a Water Supply Study performed by CH2M Hill, showed that the drought has increased the public's acceptance of water conservation programs and other methods of alleviating the water shortage, specifically use of ground water and wastewater reclamation projects. General consensus at these meetings was that although current projects and programs have helped ease the water crisis, SFWD and BAWUA should do more to manage water resources in this and future droughts.

3.3 Impact of the Drought on Industry

The severe shortage of water during the current drought and an unreliable water supply have strongly affected Northern California's industrial sectors. Two industry leaders summarize below the impact of the drought.

> "If I knew then what I know now — which is that I don't know if I am going to get water or not — I never would have expanded here in California. It's very clear that our third wafer fabrication facility won't be here... unless the government and water officials do something so we can get off this roller coaster. We can't run our business like a yo-yo."

> "All of a sudden, industry has become very sensitized that the water they have been used to in the past is not a given in the future." "Facilities that were in the planning stages have been put on hold or curtailed because of the lack of available water."

In July of 1991, Spectrum Economics presented the results of an industrial water use survey. The purpose of the survey, sponsored by California Urban Water Agencies (CUWA), was to determine the implications of reduced water supply reliability. The survey showed that manufacturing plants have already invested significant amounts of money in conservation programs and technology, and would require increasingly larger investments to further reduce agency water intake.

The Spectrum survey stated that under a hypothetical 30% water supply reduction, the impact on industry would be devastating. The surveyed industries would lose $11.8 billion in direct output for this scenario. Spectrum Economics estimated that there would be 46,000 lay-offs for the same hypothetical 30% water cutback, or approximately 5.4% of the 1989 labor force in the surveyed industry groups. According to the survey, Northern California's industries would be particularly affected.

> "Employment in Northern California's Computer and Electronic Components industries would be particularly hard-hit by a 30% water supply shortage. These two industries would sustain 66 percent of the reported job loss in northern California industry groups. Computer Components and Computer Equipment are process water intensive. Microchips are manufactured in a wet environment with much necessary rinsing. Computer Equipment manufacturing uses a lot of water for rinsing. These industry groups are the largest manufacturing employers and would sustain the largest employment reductions — 12,800, over 9 percent of Northern California employment in these industry group. Santa Clara County — Silicon Valley — would sustain the largest share of the computer industry losses."

The shortage of water has become one of the top concerns of companies planning for expansion or relocation. Industries say methods of conserving water are running out. The Spectrum survey concluded, "Eventually, as plants become more efficient in water use, fewer options exist to absorb water supply shortages and plants become vulnerable to shortage. Yesterday's conservation 'hardens' today's plant water requirement."

Another conclusion Spectrum Economics draws from the survey concerning the water situation is:

> "Lack of water supply reliability is one more business problem -- joining air pollution, traffic congestion, and housing costs -- that discourages plant and equipment investment in California. California's economic health is vulnerable to plant and equipment investment decisions by its key industries. The consequences of a reduction in the reliability of water supplied to California industry must be carefully assessed by policymakers."

It is important to note that the Spectrum survey results were hypothetical, and were not based on actual water use reductions. Current conservation programs reduce inside water use by 10%, and not by the hypothetical 30% called for in the Spectrum Survey. As explained in the next section, the San Francisco PUC did call for 33% inside water use reduction for a short period of time as part of an overall 45% reduction plan; but the duration of this reduction plan was not long enough to substantiate the Spectrum survey.

4.0 PROJECTS AND PROGRAMS CAPABLE OF EXPANDING WATER SUPPLY

Possible projects and programs that have the capability of expanding the SFWD water supply are a combination of expansion of currently implemented methods and new concepts. This section will describe projects and programs that have been used during the current drought and/or recommended by the SFWD, HHWP, and various consultants to the SFWD. While some of the projects and programs were well-documented in prior reports, others are conceptual in nature, and more analysis is needed before the capability of these projects and programs can be established.

4.1 Water Conservation Programs

Conservation differs from rationing in that it is voluntary and sustainable as a permanent source of water use saving.

The SFWD's current conservation program incorporates the "best management practices" concept set forth in the "Memorandum of Understanding for Urban Water Conservation in California," of which the SFWD was the first major water utility to sign. This MOU lists several Best Management Practices (BMPs — a policy, program, practice or rule aimed at more efficient use or conservation of water) to which the signatories have agreed. By being one of these signatories, the SFWD has committed to "make good faith efforts" to encourage implementation of the BMPs by all of its customers, including BAWUA. The SFWD has already implemented some of the 16 BMPs listed by MOU. The BMPs range from interior and exterior water audits and incentive programs to ultra low flush toilet replacement programs. The projected water savings from these BMPs range from 10% to 20% over current practices. It will take experience to determine savings possible in San Francisco's service areas. In addition, the Water Department and the BAWUA have established a committee to coordinate and fund regional conservation activities such as public service announcements on the radio, twenty-one separate information packets, and awareness curriculums for distribution in schooIs. One program implemented by the SFWD provides free leak detection for large municipal users. According to the SFWD, this leak detection program saved in 1990 at least 468,000 gallons per day in water mains and 3.9 mgd in customer systems.

To ensure a permanent water conservation program, the San Francisco Board of Supervisors passed several pioneering ordinances aimed at reducing water use. For example, in December 1990, a local ordinance was adopted which requires the installation of 1.6 gallons per flush (referred to as ultra-low flush toilets; regulars toilets use six gallons per flush). Then, in March 1991, the Board of Supervisors passed a landscaping ordinance requiring proper landscaping design and irrigation techniques to minimize water use.

4.2 Ground Water Programs

Several ground water and wastewater reclamation programs have been recently studied by the SFWD and James M. Montgomery, Consulting Engineers (JMM), a consultant to the SFWD. These studies have identified alternatives for the use of ground water and reclaimed water, estimating the yield of water from each alternative, and where noted, the costs of implementing the projects.

Ground water is surface water which has percolated into sand and gravel aquifers beneath the earth's surface and which may be drawn from wells and springs. Although this source of water has had a long history of use, proper management of the supply now and in the future is essential. Past and present anxieties about ground water center around its overdraft and quality. By excessively pumping ground water basins, some ground water projects in other jurisdictions have caused land subsidence, seawater intrusion, and the lowering of lake levels. The quality of the ground water is another concern, especially if the pumped ground water will be used as drinking water. But, with adequate programs to investigate, document, recharge and protect supplies, it is expected that ground water will continue to play an important role in the water supply.

According to the SFWD, the four counties in its service area pumped a combined average of approximately 33 mgd between 1985 and 1990. Mainly used for irrigation, the ground water also has been used as a potable supply as well as an addition to the water supply used for firefighting purposes.

Ground water projects have been discussed in two different studies: one by the SFWD in March 1990 and the other by JMM in August 1991. The SFWD study identified three alternatives for using ground water to supplement the City's potable and irrigation water supply, and the water supply used by the San Francisco Fire Department. The yield from each of these alternatives was determined to be approximately 3 mgd. The capital costs ranged from $1.7 million to $15.4 million, and the annual operations and maintenance (O&M) costs ranged from $300,000 to $700,000.

The JMM study investigated the rehabilitation of wells in the Sunset District of San Francisco to augment the City's water supply. Based on the investigation of these wells, JMM recommended the City abandon all inactive wells in the Sunset District, and test the water quality of active wells and future Sunset test wells to confirm that their quality passes Department of Heath Services (DHS) standards. JMM further recommended, if the quality of the water passes DHS standards, the City install three to four new wells capable of pumping 4 to 6 mgd on a seasonal basis.

4.3 Wastewater Reclamation Programs

Wastewater reclamation is the treating of wastewater to a sufficient quality level for beneficial use. The higher the level of treatment needed to obtain sufficient quality, the greater the cost of the reclaimed water. This high cost is the main concern over reclaimed water use. The cost of treating the wastewater to usable industrial and irrigation levels may limit the use of reclaimed water in the future. Another concern is that treated wastewater contains a high level of nitrogen, heavy metals and minerals, and once it percolates into ground water supplies, the quality of ground water may be degraded.

Reclaimed wastewater has been used at construction sites for dust control, as well as by commercial and industrial processes such as car washes and industrial cooling. But, the biggest user of reclaimed wastewater has continued to be irrigation. In the Bay Area, some highways and parks are irrigated exclusively with reclaimed water.

JMM also performed two studies on the use of reclaimed water. One study proposed the export of reclaimed water from the Bay Area for two possible uses: replacement of existing irrigation water used by San Joaquin agriculture with reclaimed water; and, replacement of freshwater used to repel saline Bay water from intruding into the Delta channels with reclaimed water. The estimated freshwater savings from these options (and sub-options) ranged from 140,000 AF per year to 364,000 AF per year, and the costs ranged from about $190 million to $385 million. Even though the costs are quite high, JMM concluded that the large yields of water make the cost per acre-foot of water for these alternatives comparable with those of other new sources of water. However, this project does not directly augment or offset San Francisco supplies.

The other reclamation study was performed by JMM as part of San Francisco's Water Reclamation Master Plan. In November 1990, JMM presented to San Francisco a report listing preliminary water reclamation alternatives for the City's review and comments. This report divided the potential users of reclaimed water in the City into the eastside users and the westside users. The report estimated the demand of reclaimed water in the City to be about 13.5 mgd; 11.0 mgd by the westside users and only 2.5 mgd by the eastside users. Two options capable of providing the reclaimed water were suggested by the report. One option called for the construction of one tertiary treatment plant along with a distribution system conveying the effluent from this plant to all potential users; the other option called for two tertiary treatment plants, each supplying one side of the City. JMM will report on the cost of implementing these options at a later date.

It should be noted that while the ground water and reclamation projects outlined here do yield a significant amount of water, this yield is comparable to the much less expensive conservation programs implemented by the SFWD. For example, the Water Department's leak detection program saved approximately 4.37 mgd in 1990. If compared with the yield of 3 to 6 mgd from ground water projects, the equivalent yield and lower implementation costs highlight the benefits of water conservation projects. Therefore, these projects' high costs and comparable water yield with lower cost projects require that a thorough investigation of other types of programs be performed before their implementation.

4.4 Water Transfers and Purchases From Other Areas

One reason why the PUC backed off from the 45% rationing plan was the availability of water transfers. The PUC has budgeted "seed" money in both its 1991-92 and 1992-93 budgets which provides SFWD with "good faith money" in dealing with potential surplus water sellers.

Successful water transfers have been accomplished resulting in the transfer of 61,400 acre feet into SFWD's system and the purchase and temporary storage of an additional 17,000 acre feet in the Kern County Water Agency's groundwater basin.[2] Transfers were made through the purchase of surplus surface and groundwater from the Placer County Water Agency, Modesto Irrigation District and the State Drought Emergency Water Bank.

All transfers were made possible through the use of the State Water Project as a transport facility. The water entered into SFWD's system at the South Bay Aqueduct turnout which was constructed under contract to the State Department of Water Resources. Although this water will become part of the total supply to SFWD's service area, the South Bay Aqueduct turnout has and will continue to be used only on an emergency basis.

The following concerns arise with the use of water transfers.

1. Water transfers can only be accomplished if a seller has surplus water. With a prolonged drought, sellers may no longer have available water, competition may be high and the reliability of water transfers decreases.

2. Water transfers through the Delta such as those described above may negatively impact Delta fisheries.

3. The ability to transport water is limited by the capacity within the State Water Project's Aqueduct.

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[2]Data through 6/30/92.

4. The quality of the water was sufficiently poor to require substantial additional treatment (approximately $400,000 for the above referenced purchases).

5. Additional pumping costs, approximately $900,000, was required.

6. The total cost of purchasing and transporting the water was substantial with the above referenced water costing approximately $22.7 million.

In 1986, Kennedy/Jenks Engineers presented to the SFWD several water transfer options as part of a study into alternative means for providing additional water. The source of water available for purchase identified by the study included the Central Valley Project, funded by the United States Bureau of Reclamation (USBR), and the USBR's San Felipe Project. Along with these water purchases, the study also recommended the diversion of water from the Delta through the State Water Project facilities along the South Bay and California Aqueducts. According to the study, the amount of water available from these options range between 20 mgd and 100 mgd. However, the long-range availability of this water is questionable. In 1986 dollars, the capital costs for these projects range from $15 million to $123 million, and the O&M costs range from $336,000 to almost $12 million.

The possible water transfers identified by Kennedy/Jenks use the Delta as part of the source and transportation of the water. By using the Delta, these options once again raise the issue of Delta water quality and its impact on public health.

4.5 Desalination Programs

Desalination is the process of removing salt from brackish water, particularly seawater, to get fresh water. As a result of the drought and because most of California's urban centers are located on the Pacific Coast, where seawater is abundant, there is an increasing interest in desalination as a possible source of supplemental water. Due to this interest, the CUWA commissioned the Boyle Engineering Corporation to prepare a report on the desalination process and the different options for implementing the process.

According to the CUWA sponsored report, desalination has a long history of use, but the use of the desalination process in California is fairly recent. A number of desalination plants treat seawater to supply water for industrial processes at Chevron's Gaviota Oil and Gas processing plant, and at three Pacific Gas and Electric Company (PG&E) plants at Moss Landing, Morro Bay, and Diablo Canyon. Because of the drought, a number of California communities are considering desalting brackish water or seawater for municipal use. The Marin Municipal Water

District, after considering desalination of San Francisco Bay water, operated a desalination plant for three months to demonstrate the feasibility of a 5 mgd (expandable to 10 mgd) plant. (They have since decided to proceed.) The Monterey Peninsula Water Management District is contemplating the construction of a 3 to 8 mgd seawater desalination plant. To also further advance the desalination process, the California Legislature is considering legislation on desalination: some to provide funding and low-cost power and others for research.

The major impediment to the desalination process is the cost of the energy required to operate desalination plants. Both of the methods of desalination discussed by the Boyle Engineering report, distillation and membrane processes, require a significant amount of energy. While improvements to equipment used in the desalination process may lower the cost of desalinated water, desalination plants will retain high operation costs unless less expensive power sources are developed. For communities now considering desalination as an alternative to gain more water, the choice is paying for more expensive water or facing the economic impact of a water shortage.

4.6 Modifying and/or Adding to Existing Water Supply System

To conclude the report, this section will discuss different options for expanding the City's water supply by modifying and/or adding to the existing water supply system. In the past, a number of reports have studied various options involving changes to the physical water system. The options described below were taken from two sources: a study of the Crystal Springs Water Treatment Plant (WTP) alternative performed by Camp Dresser & McKee (CDM) in September of 1988; and the previously mentioned Kennedy/Jenks study in 1986. The options studied by other reports are either repetitions of the options described here or are no longer relevant to the water supply system.

The purpose of the 1988 CDM study was to help the City decide whether to build a water treatment plant at Crystal Springs Reservoir, or to consider other options. Based on their research, CDM recommended that the City not build the Crystal Springs WTP at this time, but rather expand the San Andreas WTP from 120 mgd to 180 mgd. CDM based the recommendation on the fact that expansion of the San Andreas WTP would be a less expensive option for meeting system requirements. CDM estimated that the cost of the expansion ranges from $10 million to $15 million, in terms of 1988 dollars. CDM also suggested the City construct a parallel Irvington Tunnel (Irvington No. 2). This would allow for the existing 50-year old Irvington Tunnel to be taken out of service for routine inspection, maintenance, and repair during winter months. In 1988 dollars, the cost of constructing the parallel tunnel ranges from $65 million to $75 million.

Kennedy/Jenks identified four options which added to or modified the physical water supply system in order to achieve a larger water supply. The first two options described by Kennedy/Jenks involved either increasing the capacity of terminal storage facilities, or building a joint terminal reservoir and/or purchasing East Bay Municipal Utility District (EBMUD) raw water for supply to the Hetch Hetchy Aqueduct. The first option called for the raising of San Antonio Dam and both Lower and Upper Crystal Springs Dams. By raising these dams, Kennedy/Jenks suggested that water which would normally spill in wet years will be retained. The added storage in the San Antonio reservoir will enable water transfers from the Hetch Hetchy pipelines to the reservoir during above-normal years. The costs of raising these dams were estimated at $8 million in terms of 1986 dollars.

The second option called for a joint project with EBMUD. Kennedy/Jenks suggested two sub-options: the City could either build a terminal reservoir in conjunction with EBMUD, and in addition, extend the EBMUD raw water supply system to join the Hetch Hetchy Aqueduct; or the City could join with EBMUD in constructing an aqueduct from the Delta which would be able to wheel enough water for San Francisco's and EBMUD's requirements. Both of these sub-options are capable of providing more than 100 mgd to the City. The costs of implementing the sub-options are respectively $320 million and $386 million.

The remaining two options identified by Kennedy/Jenks involve the construction and replacing of two pipelines. Kennedy/Jenks suggested either constructing a fourth pipeline in the existing 100-foot wide Hetch Hetchy right-of-way, or replacing the fifty-plus year old No. 1 Pipeline with a larger diameter pipeline. By ensuring the diameters of the new pipelines are sufficiently large, Kennedy/Jenks states that both options are capable of delivering over 100 mgd. The costs of constructing the two pipelines are respectively $106 million and $126 million. However, it is important to note that these two options were suggested at a time when safe yield was thought to be 400 mgd. As explained earlier, analysis now show the system safe yield to be 235 mgd. In order to maintain the validity of these two options, additional storage either in the Sierra or the Bay Area would be required.

It must be emphasized that this is a summary of prior, and in some cases obsolete, work. Cost figures are not always comparable and should be used only as the most approximate indicator of "order of magnitude".

A useful analysis of alternatives would need to include non-facility alternatives, appropriate consideration for environmental improvements and the current understanding of system yield and operating limits. It would also have to be done in coopera-

tion with the Bay Area Water Users Association and would have to consider their independent options for obtaining water supply.

The following table summarizes the estimated yield and cost of the above projects and programs.

Suggested Projects and Programs[7]
TABLE 1

PROGRAMS	YIELD		COST		SOURCE
	mgd	AF per yr	CAPITAL millions $	per AF[8]	
GROUNDWATER					
Supplement City's Potable, Irrigation, Firefighting Water	3[1]	3,360	1.7-15.4[2]	$526-$4,770	SFWD
Sunset District	4-6	4,480-6,721	N/A	N/A	JMM
RECLAIMED WATER					
Export of Reclaimed Water[5]	125-325	140,027-364,071	190-385	$1,357-$1,057	JMM
City's Reclaimed Water Use	13.5	15,123	N/A	N/A	JMM
WATER TRANSFERS					
USBR Projects	20-100	22,404-112,022	15-123[3]	$670-$1,090	KENNEDY/JENKS
MODIFICATIONS					
Expansion of San Andreas WTP	60	67,213	10-15[4]	$149-$223	CDM
Raise San Antonio and Crystal Spring Dams	N/A	N/A	8[3]	N/A	KENNEDY/JENKS
Joint EBMUD Reservoir	100 +	112,022 +	320[3]	$2,857-	KENNEDY/JENKS
Joint EBMUD Aqueduct	100 +	112,022 +	386[3]	$3,446-	KENNEDY/JENKS
Construct San Joaquin Pipeline No. 4[6]	100 +	112,022 +	106[3]	$946-	KENNEDY/JENKS
Replace San Joaquin Pipeline No. 1[6]	100 +	112,022 +	126[3]	$1,125-	KENNEDY/JENKS

N/A - Information not available.
(1) Yield for each of the three alternatives studied.
(2) In 1990 dollars.
(3) In 1986 dollars.
(4) In 1988 dollars.
(5) This will yield additional supply only if part of an exchange agreement.
(6) These projects would require additional storage.
(7) Some of these projects may no longer be feasible due to the passage of time.
(8) Cost adjusted to January 1992 dollars used in 1992 Means Building Construction Cost Data, 50th Edition, Historical Cost Index.

1986 dollars x 1.166 = 1992 dollars
1988 dollars x 1.093 = 1992 dollars
1990 dollars x 1.042 = 1992 dollars

5.0 CONCLUSION

Existing demand is above the system's safe yield with the result that even without growth, the service area can expect to be subjected to periodic supply deficiencies.

Long term demand projections show service area demand exceeding system capacity soon after the year 2000.

Conservation, reclamation and full use of ground water supplies is and will continue to be the first line of defense in dealing with this supply squeeze. But these activities are limited in their ability to deal with long term growth. It is highly likely that the service area will need additional water supplies in the near future.

Developing new supplies is both time consuming and very expensive. This report summarized current conservation activities as well as prior proposals for new facilities. Taken together, this is a summary of water supply options that are available to deal with San Francisco's long term water supply needs.

San Francisco and the Bay Area Water Users Association have a stake in finding and supporting solutions to environmental problems caused by prior water development in California.

Because of the supply situation discussed above, Hetch Hetchy is not in a position to contribute water from its existing facilities for environmental improvements. But, as plans are made to secure future supplies, provision will have to be made for the environment. And in the meantime, there may be non-water contributions that San Francisco can and should make.

Consideration of these options suggests five essential elements of a viable water supply policy:

1) Hetch Hetchy and the City Attorney should resist all attempts to divert existing project yield to new or expanded purposes.

2) The Water Department should continue and expand current efforts in conservation, reclamation, and ground water development in a committed attempt to stabilize net system demand at or near current levels.

3) Hetch Hetchy needs to pursue "dry year options" and other forms of supply augmentation that will increase safe yield to at least the level of current system capacity. This is in recognition of the resulting, decreased ability of the service area to sustain supply deficiencies as increased conservation "hardens" the service area's water demand.

4) In order to deal with the likelihood that these necessary steps will prove insufficient, Hetch Hetchy, the Water Department and the Bay Area Water Users Association need to evaluate the need and possibilities for increasing supplies. This could be in the form of increasing Hetch Hetchy's capacity or increasing the suburban water agencies' ability to utilize other supplies. Population trends, land use and environmental considerations need to be part of this evaluation.

5) Hetch Hetchy and the Water Department should work together with other California water and environmental interests to identify opportunities for financial participation in projects that will create new water or facilities that will contribute to the restoration of environmental conditions in the San Joaquin River Basin and in the Bay/Delta Estuary. Future water projects should be designed with the intent of improving environmental conditions where feasible.

Appendix A

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